

North Carolina

DEPARTMENT OF TRANSPORTATION

Pavement Marking Life Cycle Cost Analysis

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Overview

- NC pavement markings include paint, thermoplastic, cold applied plastic and polyurea.
- This research was coordinated by the NCDOT Signing & Delineation Unit.
- Based on cost-benefit ratio, these results can be used to assist in the selection of pavement marking materials for roadways based on ADT and needed service life.
- The basis for this pavement marking life cycle research is the retroreflectivity of the material which is measured in mcd/lux/m².

History

- Started taking mobile readings around 2000 until the markings were replaced.
- Over 9700 line miles were read.



What do we do with the data?

Parameters & Equations

- Equations
 - Extruded Thermoplastic
 - The Extruded Thermoplastic models used are shown below:

Yellow: $R_L = 190 + (0.39 * R_{L \text{ Initial}}) - (2.09 * \text{Time}) - (0.0011 * \text{AADT}) - 39.7$

White: $R_L = 190 + (0.39 * R_{L \text{ Initial}}) - (2.09 * \text{Time}) - (0.0011 * \text{AADT}) + 39.7$

Parameters & Equations

- Paint
- The model for paint is as shown:

$$R_L = 55.2 + (0.77 * R_{L \text{ Initial}}) - (4.17 * \text{Time})$$

- Equations came from NCSU report “Pavement Marking Performance Analysis” by Dr. Joseph Hummer, et. al.
- In this study data collected from NC roads was used to create degradation models for extruded thermoplastic and paint.

- Notes for Equations

- R_L – Final Retroreflectivity in mcd/lux/m²
- $R_{L\text{ Initial}}$ - Initial Retroreflectivity in mcd/lux/m²
- Time - Time since installation in Months
- AADT - Annual Average Daily Traffic in Vehicles Per Day
- Data used to develop the paint model has an average AADT of 1300

Parameters & Equations

- Initial Retroreflectivity Values
 - The initial retroreflectivity values are based on the minimum standards for each material from the NCDOT 2012 Standard Specifications for Roads and Structures.
 - Higher initial retroreflectivity values increase life to a certain point
- Values Used in Research Study
 - Paint: 200 mcd/lux/m²(Yellow) and 225 mcd/lux/m²(White).
 - Extruded Thermoplastic with Standard Beads: 250 mcd/lux/m²(Yellow) and 375 mcd/lux/m²(White).
 - Polyurea with Highly Reflective Elements: 500 mcd/lux/m² (Yellow), 800 mcd/lux/m² (White)

Material Cost

- Extruded Thermoplastic
 - 4" X 90 Mil (Edge) - \$0.45 (Std), \$0.62 (HRE) installed
 - 4" X 120 Mil (Middle) - \$0.55 (Std), \$0.72 (HRE) installed
- Paint
 - All - \$0.12 installed per coat
 - Permanent paint markings require 2 coats (\$0.24)
- Polyurea
 - All - \$0.65 installed (HRE)

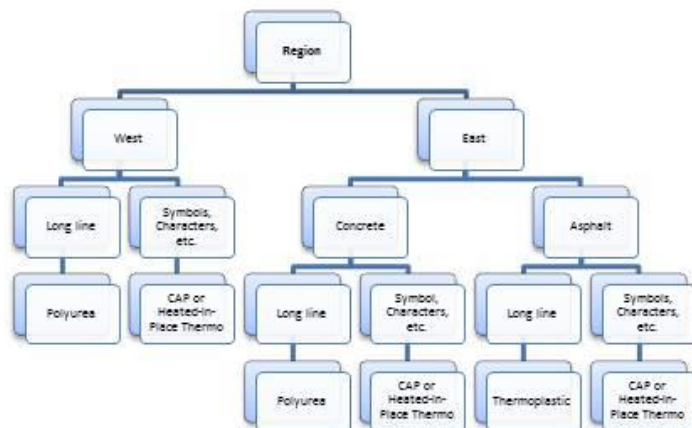
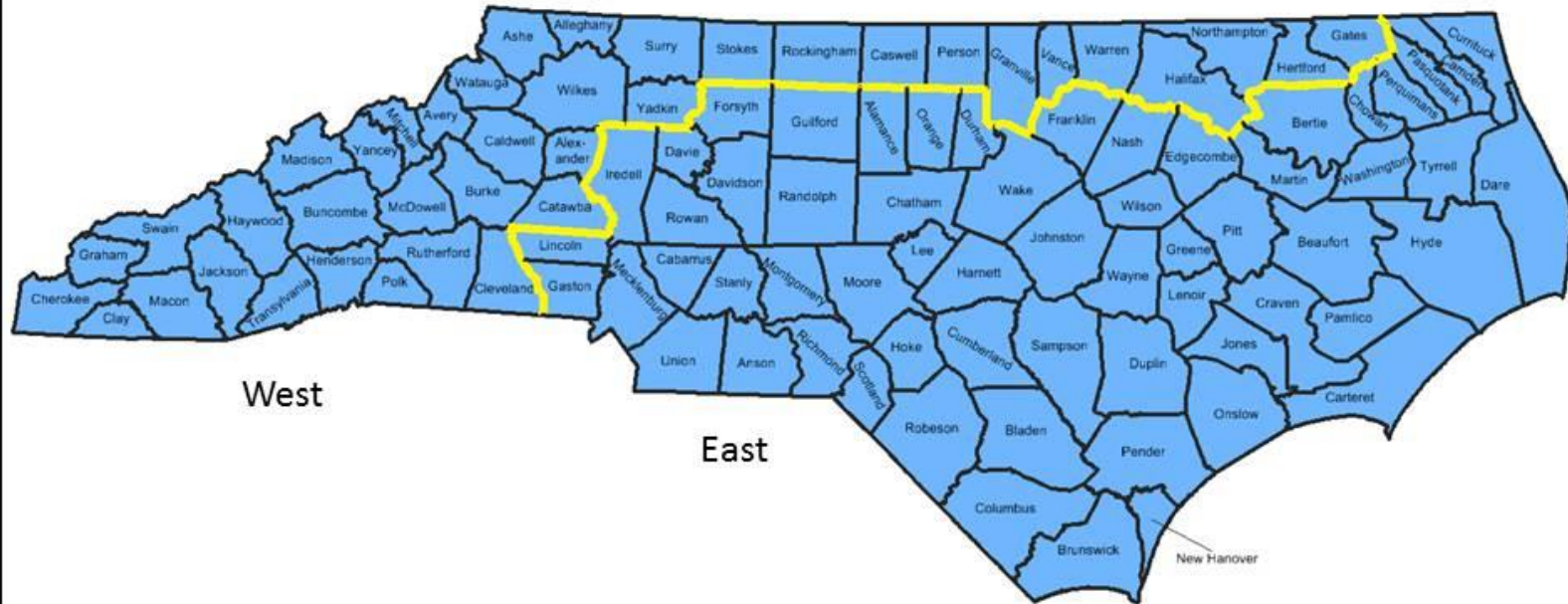
Assumptions for Cost Analysis

- The following analysis is based on these criteria:
 - The final retroreflectivity (R_L) value used was 100 mcd/lux/m².
 - Final Retroreflectivity value based on information from AASHTO, MUTCD subcommittee, and Paul Carlson (TTI) study.
 - Paint pavement markings will have a life of approximately 1 year when placed in moderate to heavily snowplowed areas.
 - Yellow center lines wear quickest due to color and location in roadway.

Chart Explanation

- Charts 1 – 4 show cost per mile on a 2 lane road for four different materials at four different AADTs based on time.
- Charts 5 – 8 show cost per mile on a 2 lane road with moderate to heavy snowplowing for two different materials at four different AADTs based on time.
- Materials shown:
 - Paint with Standard Beads
 - Thermoplastic with Standard Beads
 - Thermoplastic with Highly Reflective Elements
 - Polyurea with Highly Reflective Elements

Pavement Marking Material Selection

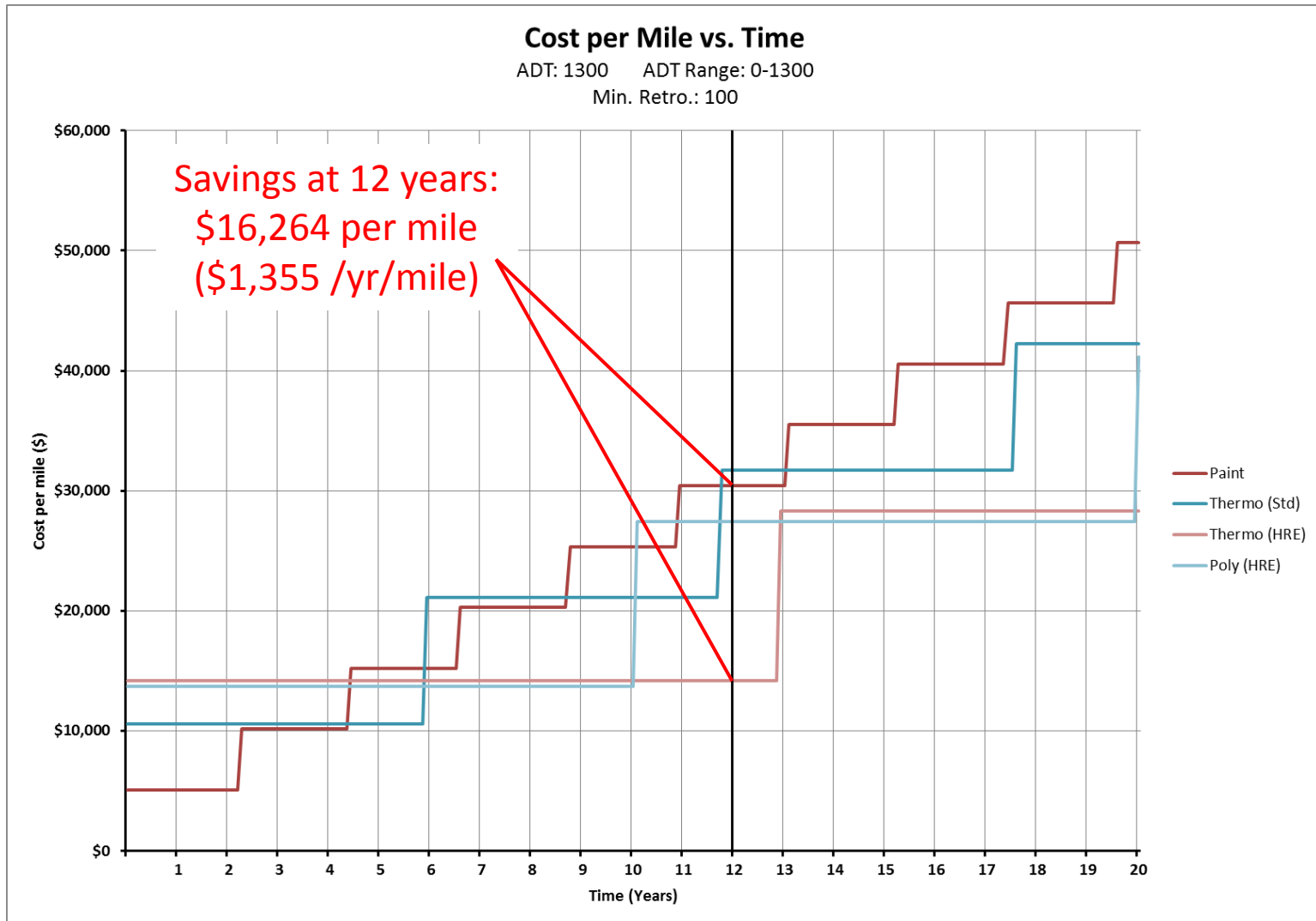


Notes:

-All bike lane markings should be heated-in-place thermoplastic

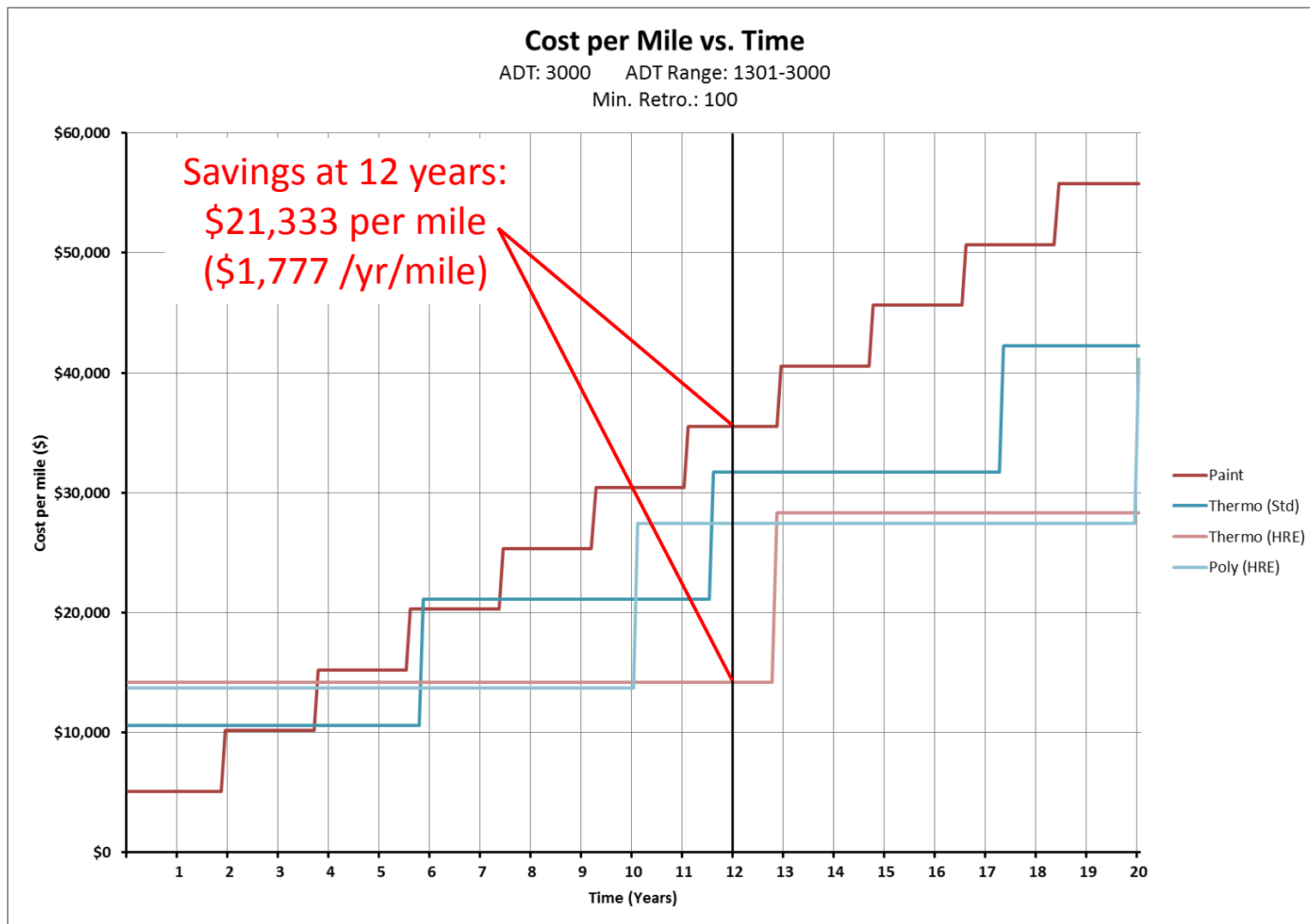
Results

1.



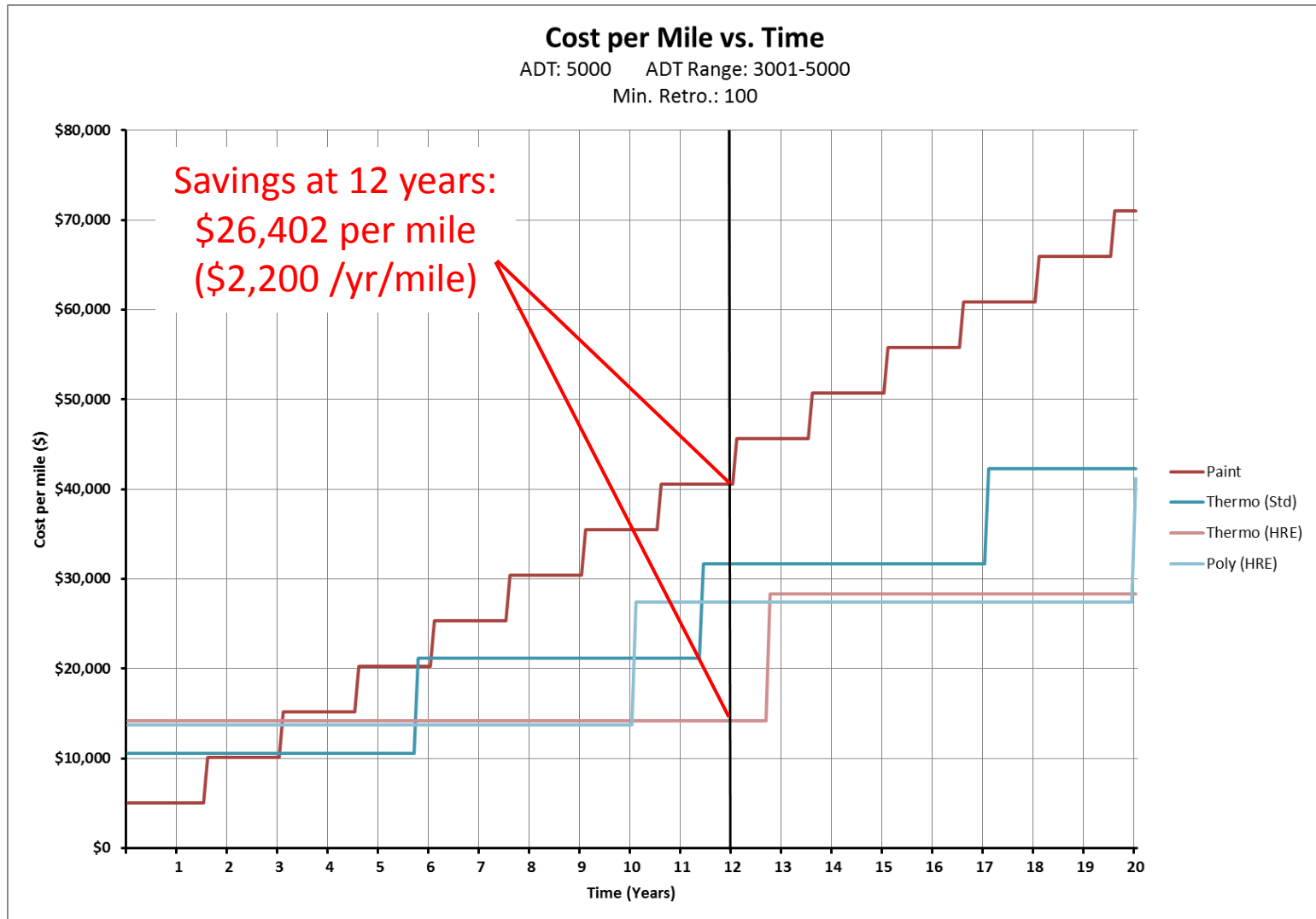
Results

2.



Results

3.



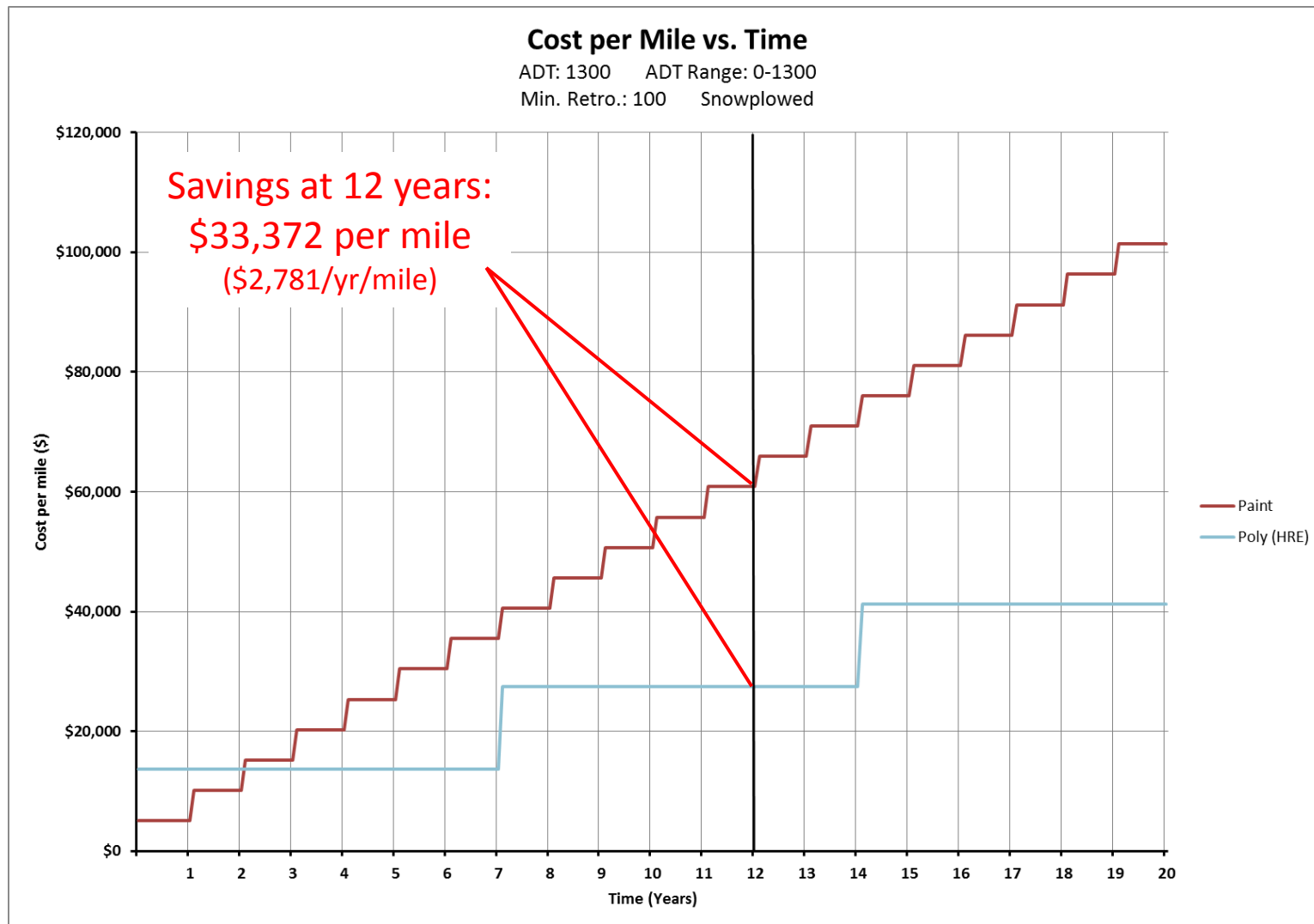
Results

4.



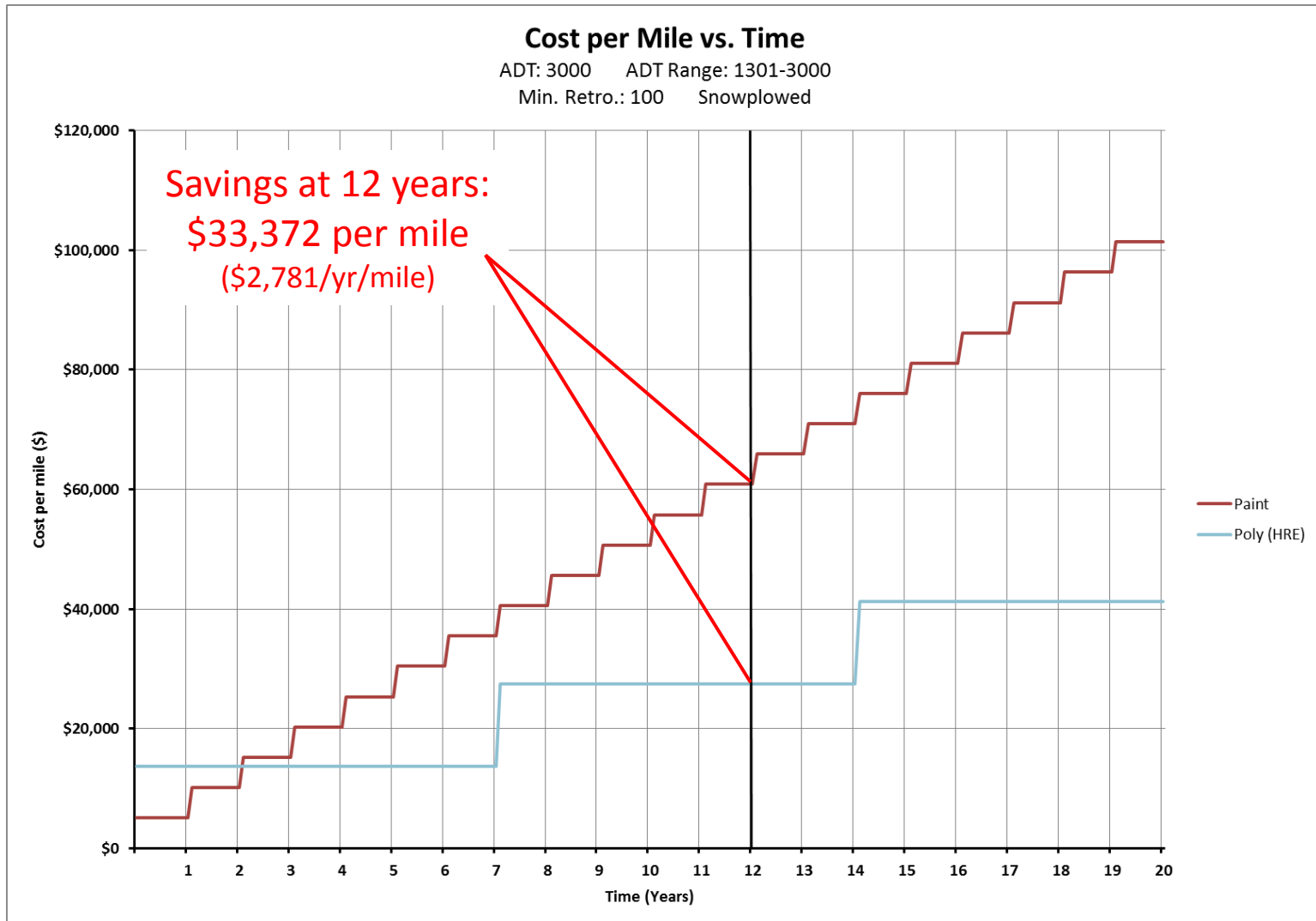
Results

5.



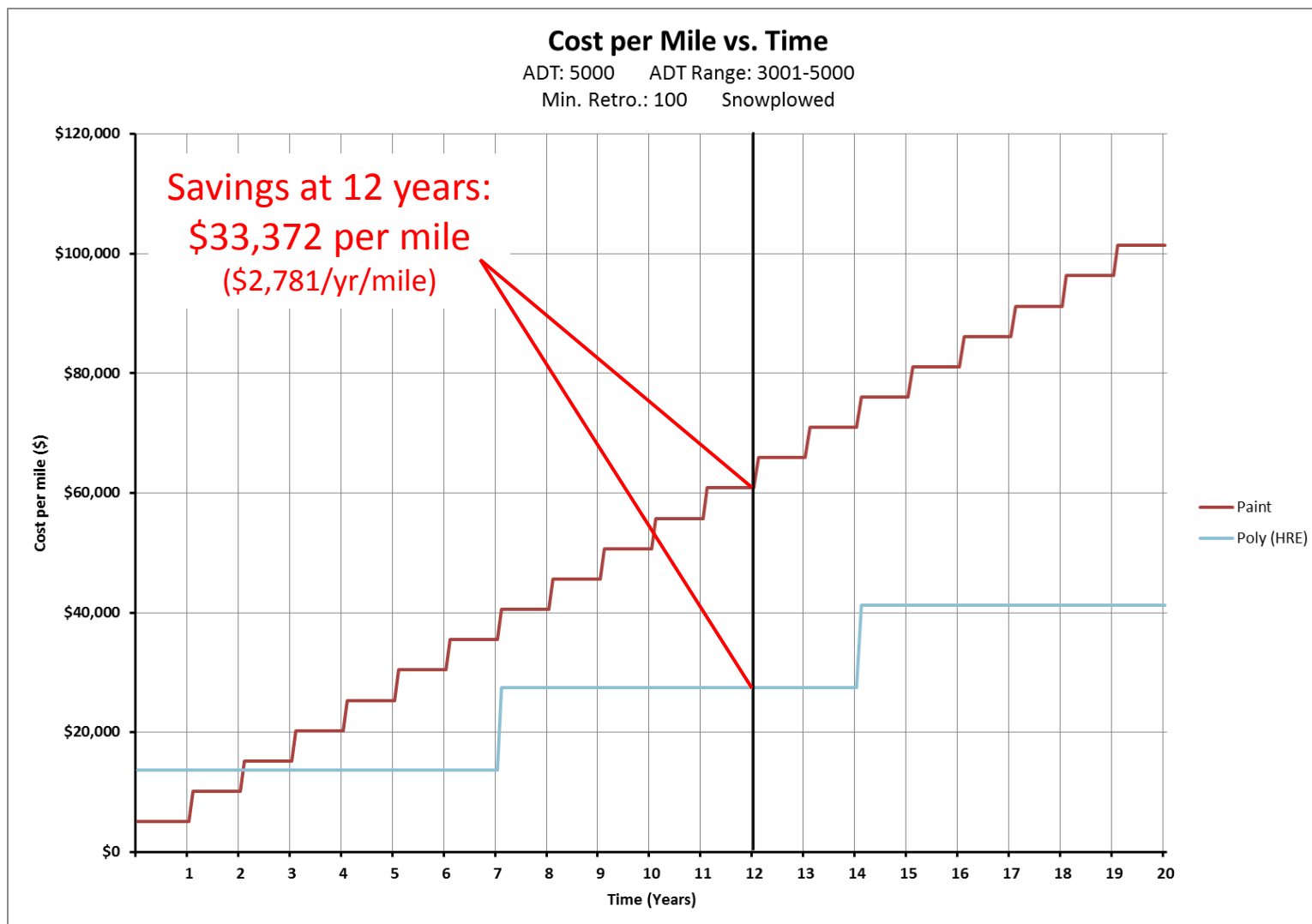
Results

6.



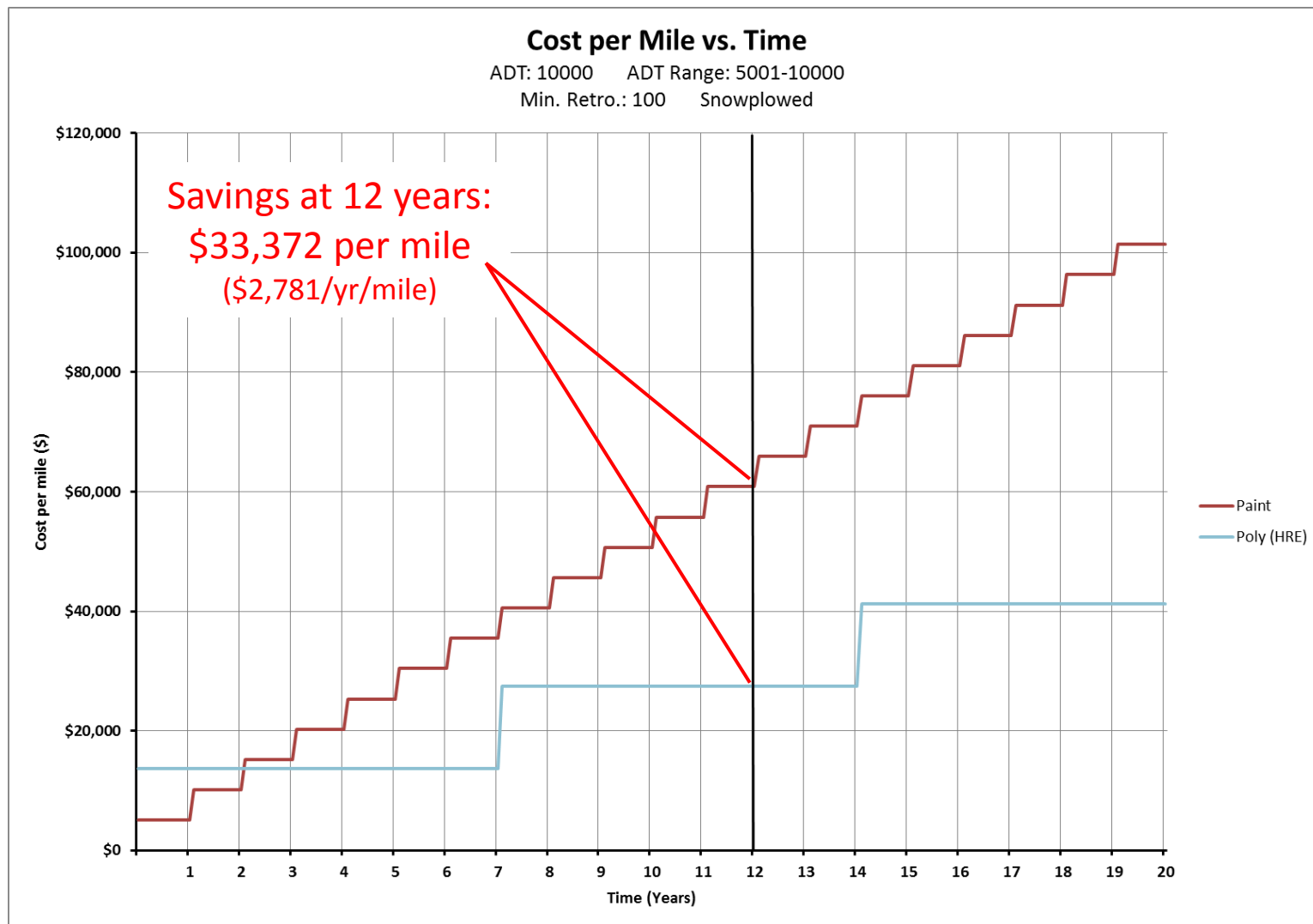
Results

7.



Results

8.



Summary of Analysis

Cost per mile at 12 Years

<u>AADT</u>	<u>Material</u>			
	Paint	Thermo (Std)	Thermo (HRE)	Poly (HRE)
1300	\$30,414	\$31,680	\$14,150	\$27,456
3000	\$35,483	\$31,680	\$14,150	\$27,456
5000	\$40,552	\$31,680	\$14,150	\$27,456
10000	\$60,828	\$31,680	\$14,150	\$27,456

Cost per mile at 12 Years - Snowplowed

<u>AADT</u>	<u>Material</u>	
	Paint	Poly (HRE)
1300	\$60,828	\$27,456
3000	\$60,828	\$27,456
5000	\$60,828	\$27,456
10000	\$60,828	\$27,456

 Most Cost Effective

Summary of Analysis

	Savings per Year Using Long-Life Markings				
	ADT Range				
Division	0-1300	1301-3000	3001-5000	5001-10000	Total
Division 1	\$476,000	\$176,000	\$139,000	\$183,000	\$974,000
Division 2	\$122,000	\$50,000	\$42,000	\$78,000	\$292,000
Division 3	\$508,000	\$243,000	\$174,000	\$331,000	\$1,256,000
Division 4	\$89,000	\$44,000	\$31,000	\$43,000	\$207,000
Division 5	\$256,000	\$140,000	\$123,000	\$276,000	\$795,000
Division 6	\$474,000	\$233,000	\$174,000	\$292,000	\$1,173,000
Division 7	\$423,000	\$309,000	\$251,000	\$486,000	\$1,469,000
Division 8	\$778,000	\$313,000	\$196,000	\$408,000	\$1,695,000
Division 9	\$65,000	\$44,000	\$35,000	\$70,000	\$214,000
Division 10	\$211,000	\$87,000	\$64,000	\$202,000	\$564,000
Division 11	\$1,071,000	\$467,000	\$259,000	\$295,000	\$2,092,000
Division 12	\$684,000	\$339,000	\$253,000	\$303,000	\$1,579,000
Division 13	\$1,021,000	\$417,000	\$192,000	\$261,000	\$1,891,000
Division 14	\$954,000	\$264,000	\$189,000	\$222,000	\$1,629,000
Total	\$7,132,000	\$3,126,000	\$2,122,000	\$3,450,000	\$15,830,000

Notes:

- Total mileage marked from statewide 2014 data.
- Estimated mileage marked in each Division is based on average percent of 4" paint marking from the past 5 years.
- Estimated mileage marked in each ADT range is a weighted percentage of each Division's total mileage in that range.
- Division 11 – 14 have moderate to heavy snowplowing

Requirements & Options

- Anticipated Federal Requirements
 - The next version of the MUTCD will likely have minimum retroreflectivity values for pavement markings.
 - Our current practices will not meet these requirements as a whole on our roadway system.
- Options
 - Spend more money marking roadways or,
 - Become more efficient with the money we have by using long-life pavement markings.

Recommendations

- The second option proves to be the most cost effective.
- Immediate Actions
 - Use long-life final markings on all TIP and Resurfacing projects, and in all cases where it is cost effective.
- Future Solutions
 - Use long-life markings on all final applications.
 - This would also lessen worker exposure.

Conclusions

- Expected Results
 - Systematically meet minimum retroreflectivity requirements.
 - Save an estimated \$15,800,000 a year statewide.
 - A majority of these savings will be from the Highway Fund – General Maintenance.
- State Forces
 - Eventually minimize or phase out utilization of state forces for pavement marking operations.

Questions / Comments